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BIOGAS GENERATION FROM WATER HYACINTH: ALTERNATIVE OPTION FOR RURAL ENERGY REMARK

***Pallavi Sharma, Shweta Gupta, Neha Chauhan, and Jyoti Meena**
Department of Microbiology, University of Kota, Kota,(RJ),India
Corresponding author: Pallavi Sharma
Email: drsharmapallavi10@gmail.com

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Abstract
In many regions of the world, water hyacinths are starting to become a hazard in lakes, ponds, and rivers. This essay includes a review of the literature on several applications for water hyacinths, mostly in agriculture or alternative energy systems. According to the examination of the literature, water hyacinths can contain up to 3.2% of dry matter (DM) nitrogen and have a C/N ratio of about 15. The water hyacinth can serve as a substrate for the creation of compost or biogas. Nearly all of the substrate's nutrients are present in the biogas process's sludge, which may be utilized as fertilizer. Compost made from water hyacinths has increased yields for a variety of crops. The water hyacinth may be used as chicken, goat, sheep, and cow fodder due to its high protein content. Due to its prolific growth and high nutrient concentrations, water hyacinth has a great deal of potential as both a cattle feed and a fertilizer for the nutrient-poor soils of Africa. Due to the minimal nutrient losses and labor demands, applying water hyacinths directly to the soil after sun drying appears to be the best option for small-scale application. A potential solution to the world's rising energy needs is biogas generation, although this would present significant challenges in poorer nations where the water hyacinth is frequently found. Compared to dried water hyacinths, composting as an alternative treatment has the benefit of a product that is simple to work into the soil. This is due to the disintegrated structure. Water hyacinth harvesting and transportation can be done manually on a simplistic level without the need of a novel harvesting method.

Key words: *Biogas, Water hyacinth, Biomass, Renewable energy, Carbon-nitrogen ratio.*

Introduction

Biogas is a clean and environment friendly fuel produced through the anaerobic digestion of organic wastes such as: cow-dung, vegetable wastes, municipal solid waste, and industrial wastewater. It is increasingly becoming important in domestic and industry as fuel due to its costs and cleanliness. The main component of the gas is methane, carbon dioxide, hydrogen, nitrogen, and hydrogen sulphide. Water hyacinth can be used as a potential feedstock for biogas production due to its abundance and high carbon-nitrogen ratio. This study aims at evaluating the potential of utilization of water hyacinth for biogas production.

Water Hyacinth

Regarded as a hopeful and long-lasting technique of reducing water hyacinth populations. *Eichhornia crassipes*, sometimes known as water hyacinth, is a damaging invasive alien species (IAS). It is a native of the Amazon basin in South America, it has spread throughout worldwide. *E. crassipes* poses a hazard to human health, environmental function, socioeconomic growth, and the lives and sources of income of the poor. Due to the severity of the infestations to their local habitats, this compelled African nations to sign up to a number of international environmental conventions and establish their national response plans.

Chemical, mechanical, and biological control methods are the three most often utilized methods. Chemical control is quite affordable, but it is unlikely to be employed as a long-term solution due to its negative impact on the ecosystem. On the other hand, mechanical control calls for the employment of equipment and has been seen to recover large volumes of biomass. Despite its promise, it is quite expensive because of the high cost of mechanical equipment, labor, and the original investment. As a result of its capacity to reduce invasive species' competitive advantages over native plants, biological management is typically difficult.

1. Cultivation of water hyacinth

Water hyacinths grow back profusely from stem pieces, and the seed can survive for up to six years. Controlling the weed is extremely tough due to these methods of regeneration. In conditions of high warmth and humidity, the number of plants can more than quadruple in seven days, and up to 140 tons of DM/ha each year are produced. The plant may cover enormous sections of the water's surface and typically creates cohesive floating mats. Winds are also suggested to facilitate the water hyacinth's spread. The plant thrives in nutrient-rich water and on nutrient-rich shallow coastlines.

To estimate how much of a certain water hyacinth product (soil amendment, fertilizer, gas, fodder, etc.) can be produced, it is necessary to make approximations of how much biomass can be harvested. Some studies estimate the possible harvesting of water hyacinths to 320 ton of DM/ha and yr. The study is based on conditions in Bangladesh, and nothing is said about how much water hyacinth was present before the harvest started. In order to not over estimate the yield, we assume that no more than the yearly production of biomass can be harvested, i.e., 140 ton of DM/ha and yr. The water hyacinth mats are driven by the wind. The harvest possibilities will, therefore, depend on the local conditions and winds.

2. Harvesting of Water Hyacinth

Harvesting water hyacinths entails mechanical growth control. Currently, water hyacinths are only harvested to prevent their spread in areas where chemical or biological approaches (such as the introduction of insects that devour water hyacinths) are illegal or ineffective. This is because mechanical harvesting is excessively costly and time-consuming, the benefits of mechanically managing water hyacinths are as follows:

- The removal of superfluous nutrients
- The immediate result without damage to the ecosystem.
- Water bodies can be used more widely (e.g., for irrigation of agriculture areas and drinking water supply).
- Mechanical methods are possible in open flowing as well as in closed water systems.

Biogas

Biogas is lighter than air and ignites at a temperature of about 700 °C (diesel oil ignites at 350 °C; gasoline and propane ignite at a temperature of around 500 °C). The flame has an 870°C temperature. Methane (CH_4) and carbon dioxide (CO_2) make up roughly 60% and 40%, respectively, of biogas. Additionally, it includes trace amounts of other compounds, up to 1% hydrogen sulphide among them (H_2S). The longer the digestive process takes, the higher the methane level and, thus, the calorific value. If the retention duration is short, the methane level drops to as little as 50%. Biogas is no longer flammable when the methane level is significantly below 50%. Methane levels are too low in the initial gas produced by a freshly filled biogas plant. Therefore, the gas produced during the first three to five days must be released unused. The temperature of digestion affects the methane content. High methane content is generated at low digestion temperatures, but less gas is then produced.

In this work, the efficacy of the innovative anaerobic digester for producing biogas from water hyacinth in untreated, pretreated, and co-digested forms was examined in a continuous manner. The innovative anaerobic digester had a quick start-up since biogas production began right away after water hyacinth was introduced, which suggests that the inoculum (cow dung) began acclimating to the water hyacinth environment. As the OLR was raised, a linear rise in biogas generation was seen. Due to the appropriate stability and adequate buffering capacity provided in the experimental system, biogas production was observed to decrease at OLR values higher than the optimal OLR, suggesting that the activity of methanogenic bacteria was not impaired up to OLR values of 3.75 kg COD/m3. d for untreated, pretreated water hyacinth and 6.70 kg COD/m3. d for co-digested water hyacinth. After the first start-up, increased mixing helped with the mass transfer of nutrients and accelerated the water hyacinth's digestion.

Due to their susceptibility to high mixing intensity, bacteria may be hampered by extremely strong mixing. stated that operating circumstances of a two-stage anaerobic digester favour the fermentation of the feedstock and the buildup of VFA, whereas the VFAs from the first stage's effluent favor the generation of methane in the second stage. However, it is important to note that the biogas production was lower for the untreated and co-digested water hyacinth than for the pretreated water hyacinth, indicating that pretreatment of water hyacinth significantly reduced the viscosity of the feedstock, enabling more effective mixing and thereby enhancing biogas production. Additionally, the inoculum used to feed the pretreated water hyacinth included digested untreated water hyacinth together with acclimated cow manure, which provided a variety of microorganisms involved in the metabolic process and enhanced biogas generation.

Additionally, found that the efficacy of the anaerobic digestion process is significantly impacted by differences in the composition of the microorganisms at startup. As a result, the continuous anaerobic digestion process of water hyacinth was significantly affected by the fluctuation in the microorganism composition in the anaerobic inoculum. The conversion of soluble organic matter into biogas was favorably impacted by the relative abundance of a well-adapted anaerobic bacterial population during the start-up. The use of food waste in addition to water hyacinth may be the cause of the lower biogas generation from co-digested water hyacinth when compared to pretreatment water hyacinth. Because food waste rapidly degradable because bacteria that quickly grow and break down proteins and carbohydrates cause VFA to accumulate. Water hyacinth was co-digested with food waste in this study, preventing VFA accumulation due to natural buffering action in the anaerobic co-digestion process and balanced nutrients, which led to higher biogas production than untreated water hyacinth but less biogas production than pretreated water hyacinth. Following startup, the biogas output rose along with the rise in OLR until a point was reached that caused the biogas production to decline. Based on these phenomena, the OLR of the feedstock in the innovative anaerobic digester can be fixed, and the output of biogas may be managed. Intermittent mixing and the use of two stages during the continuous anaerobic digestion process were advantageous because they promoted the development of methanogens, which improved the degradation of the complex lignocellulosic water hyacinth, reduced process instability issues, and produced a significant amount of biogas while requiring less energy for maintenance. According to a study two stage anaerobic digestion produces 10.8% more methane than single stage anaerobic digestion.

Methane (CH4) and carbon dioxide (CO2) are the two chief components of biogas. CH4 content in biogas is the primary indicator of the quality of biogas. Generally, the higher the CH4 content in biogas better is the quality of biogas produced during anaerobic digestion. In this study, the CH4 and CO2 content of the produced biogas were quantified every fifth day throughout the continuous anaerobic digestion process. In the initial days, CH4 content was comparatively lower, and it started increasing gradually, illustrating that the inoculum is familiarizing itself to the environment of water hyacinth. CH4 content was observed to be 51.98, 63.67 and 55.25% for untreated, pretreated, and co-digested water hyacinth respectively on the very first day. After a few days of initiation, the CH4 content maintained a relatively stable value throughout the continuous anaerobic digestion process. CH4 content was demonstrated to be in between 57–61 %, 68–71 % and 60–63 % for untreated, pretreated, and co-digested water hyacinth, respectively. Survey that reported 70% increase in the release of biogas from the liquid digestate in intermittently mixed digesters during mixing periods thereby suggesting that the release of biogas is hampered when not mixed and mixing increases the mass transfer of the gas from the liquid phase.

Advantages & Uses of Biogas

In 2011, India started a new initiative with the aim to demonstrate medium size mixed feed biogas-fertilizer pilot plants. This technology aims for generation, purification/enrichment, bottling and piped distribution of biogas. India approved 21 of these projects with aggregate capacity of 37,016 cubic meter per day, of which 2 projects have been successfully commissioned by December 2011.

This Programme aims to install small scale biogas plants for meeting the cooking energy needs in rural areas of India. During 2011, some 45000 small scale biogas plants were installed. Cumulatively, India has installed 4.44 million small scale biogas plants.

India has additionally commissioned 158 projects under its Biogas based

Distributed/Grid Power Generation programme, with a total installed capacity of about 2 MW. India is rich in biomass and has a potential of:

- 16,881MW (agro-residues and plantations),
- 5000MW (biogase cogeneration) and
- 2700MW (energy recovery from waste).

Benefits of Biogas:

1. Availability of power at affordable rates has the following benefits:
2. Reduces pollution
3. Reduces time wastage while collecting firewood
4. Reduces reliance on fossil fuels
5. Lowers fuel import bill
6. Saves on the environment (Reduces deforestation)
7. Improves living standards in rural areas.
8. Reduces global warming
9. Produces good quality enriched manure to improve soil fertility.
10. Effective and convenient way for sanitary disposal of organic wastes,.
11. Improving the hygienic conditions.

Conclusion

Form above literature we come to the following conclusions regarding water hyacinth.

1. Removing water hyacinth promotes cleaning of river.
2. It reduces harms to ecosystem.
3. It is also used in producing bio product as discussed.

From this study we can conclude that a commercial method should be developed to control and removing of water hyacinth.

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